KEITHLEY INSTRUMENTS

INSTRUCTION MANUAL

MODEL 370

RECORDER

M7315/1066

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof (except tubes and batteries) which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the factory, DDD 216-795-2666. You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

Keithley Instruments maintains a complete repair service and standards laboratory in Cleveland, and has an authorized field repair facility in Los Angeles.

To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

TABLE OF CONTENTS

Section	Page
1. GENERAL INSTRUCTIONS:	
1-1. Introduction	1
1-2. General Description	1
1-3. Specifications	3
2. OPERATING INSTRUCTIONS:	
2-1. General	5
2-2. Connections	5
2-3. Charting Procedures	9
2-4. Chart Drive Controls	11
2-5. Inking Procedures	11
2-6. Zero Adjust	13
2-7. Calibration Adjust	14
2-8. Inspecting Chart Record	14
2-9. Chart Removal	15
3. PRINCIPLE OF OPERATION:	
3-1. General	17
3-2. Input Amplifier	17
3-3. Meter Movement	18
3-4. Chart Drive	19
4. MAINTENANCE INSTRUCTIONS:	
4-1. General	23
4-2. Inking System	23
4-3. Zero Adjust	24
4-4. Pen Balance	24
4-5. Calibration	24
4-6. Chart Drive Adjustments	25
4-7. Disassembly	27
4-8. Cleaning and Lubrication	28
4-9. Troubleshooting	29
4-10. Replacement Parts	30
SUPPLEMENT EVENT PEN ATTACHMENT:	
1-1. Description	S-1
1-2. Operating Proc.	S-1
1-3. Adjustments	S-2
1-4. Maintenance	S-2

NOTE: A change notice sheet may be included in the back of this manual describing late moditications and corrections to this publication.

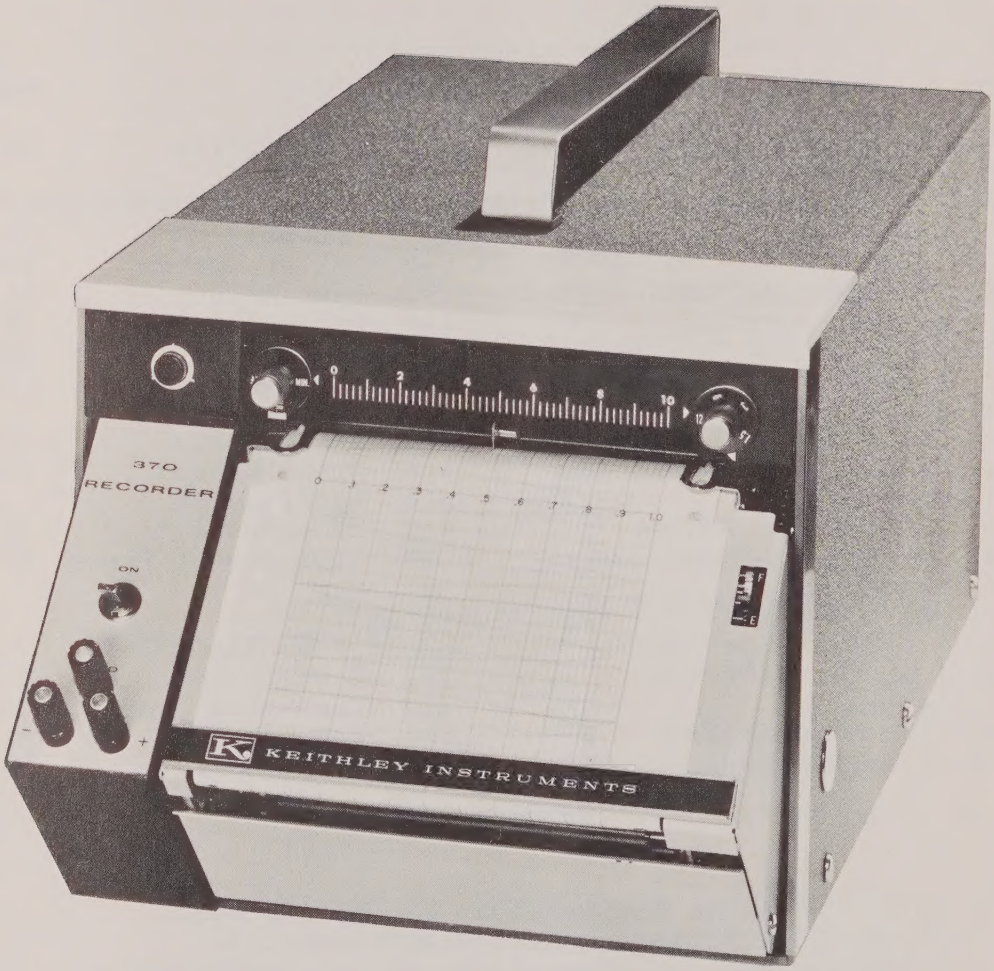


Figure 1. Keithley Instruments Model 370 Recorder.

SECTION 1

GENERAL INSTRUCTIONS

1-1 INTRODUCTION

a. The Keithley Instruments Model 370 is a recorder uniquely compatable with Keithley electrometers, microvoltmeters and picoammeters. The Model 370 Recorder operates easily with these instruments and will not degrade performance, even in the most critical applications. Using this particular instrument with the outputs from other Keithley models avoids interface problems often encountered between a measuring instrument and a recorder.

b. When used with other Keithley models, as preamplifiers, the Model 370 forms a recording system with better specifications and performance than other available systems. It can be used to record DC potentials from nanovolts to kilovolts. It can be used to record from source impedances of milliohms to 10^{12} ohms. It can be used to record currents from 10^{-14} to 10^{-1} ampere.

c. Response time of the Model 370 Recorder is 0.5 second; linearity is $\pm$1% of full scale. Ten chart speeds -- from 3/4 inch per hour to 12 inches per minute -- are selectable with front panel controls. The 6-inch chart has a rectilinear presentation. The 370 Recorder has a self-priming inking system. Chart paper and ink refills are easy to install.

d. Designed especially for Keithley Instruments, the Model 370 Recorder is manufactured by Esterline Angus Instrument Company. The long established Esterline Angus design is used to translate curvilinear movement, from a permanent-magnet moving-coil element, into rectilinear movement of the writing pen. The translating mechanism is designed to operate with a minimum of components, which results in reliable, trouble-free operation.

1-2 GENERAL DESCRIPTION

a. The Model 370 Recorder is housed in a portable metal case with large carrying handle for a convenient "center-of-balance" grip. A hinged lid is provided at the top-front of the case for quick access to the chart-transport release lever and writing elements. Front panel features include three universal-type binding posts, a scaleplate, chart-drive controls, and an amplifier on-off switch with indicator lamp.

b. A portion of the chart transport protrudes from the front of the case, thus offering the operator a convenient writing table for making notations on the recorded chart. The small panel just to the left of the writing table contains universal-type binding posts for signal inputs ---- plus the main power switch.

c. A separate power cord and wall-plug adapter is supplied with each portable recorder. The socket of this cord attaches to an inter-lock type plug on the rear of the case. Directly above the power connector is a line fuse which protects all AC-powered components within the instrument.

d. Removing the backplate on the rear of the case exposes the terminal connections that are provided for various functions of the instrument. A Terminal Code Plate listing all connection instructions is found on the inside surface of the backplate.

e. The recorder chassis incorporates three major sections: The chart transport assembly, which is found at the front of the chassis; the graphic measuring element, centrally positioned; and the chart-driving mechanism, located near the rear. Each section has been carefully designed with modular components to facilitate servicing and parts replacement.

f. The measuring system in the Model 370 includes a built-in, impedance-matching amplifier and a d'Arsonval-type meter movement. A pen-and-ink system is employed as a method of recording the analog signal on the moving strip chart.

1-3 SPECIFICATIONS

INPUT: One milliampere for full-scale deflection. A built-in, continuously-variable resistor permits use with one through five-volt sources (at 1 milliampere) in addition to current sources. Convenient screw terminals permit addition of an auxiliary resistor (not supplied) to increase the voltage range.

LINEARITY: ±1% of full scale.

DISPLAY: Rectilinear.

CHART WIDTH: 6 inches.

RISE TIME (1-99%): Less than 0.5 second.

POLARITY: Manual adjustment selects left-zero (positive or negative)or center-zero operation.

CHART DRIVE: 10 speeds; 3/4, 1-1/2, 3, 6, and 12 inches per minute or per hour.

ISOLATION: Circuit ground to chassis ground; Over 10^{10} ohms shunted by 500 picofarads. Circuit ground may be floated up to ±500 volts with respect to chassis ground.

WRITING SYSTEM: Ink with built-in primar and 6-cc disposable ink cartridge. Height of cartridge is adjustable to permit optimum inking for each application.

AMBIENT TEMPERATURE RANGE: +20° to +120°F.

CONNECTORS: Input and Ground; Binding Posts.

POWER: 105-125 volts, 60 Hz. 105-125 volts, 50 Hz & 210-250 volts, 50 Hz models available.

DIMENSIONS, WEIGHT: 8-1/2" high X 10" wide X 19-1/2" deep; net weight, 31 lbs.

ACCESSORIES SUPPLIED: Model 3701 Input Cable, Model 3702 Chart Paper, two Model 3703 Ink Cartridges, Pen Primer and Pen Cleaner.

ACCESSORIES AVAILABLE:

Model 3701 Input Cable: 6-foot cable has a banana plug to mate Model 370 input and a two-pin connector to mate the Amphenol 80-PC2F output connector used on most Keithley instruments.
Model 3702 Chart Paper: 103-foot roll of 6" chart paper. Grid is 4-1/2" wide with 10 major divisions, 50 minor divisions. Time axis has 1-1/2" major divisions and 1/4" minor divisions.
Model 3703 Ink Cartridge: 6 cc cartridge of red recorder ink.
Model 3704R Event Pen Kit: Pen mounts on right side of recorder, deflects about 1/10" toward center of chart and can follow ten complete "on-off" cycles a second. Pen (red ink) operates on line voltage.
Other voltages available on special order.

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_06124

SECTION 2

OPERATING INSTRUCTIONS

2-1 GENERAL

a. Do not attempt to put this instrument into operation until all instructions have been thoroughly studied. Failure to make proper connections or to service the inking system at regular intervals may result in unsatisfactory operation or permanent damage to the instrument. If recommended procedures are followed, the recorder can be expected to give continuous trouble-free service.

b. When unpacking the instrument, refer to the packing slip listing all enclosed items. Check off the items as they are unpacked; if anything is missing, go through the packing material carefully before throwing it away. After removing the instrument from its packing case, inspect the unit for physical damage. See that the chart transport latches securely in position, and that all panel control knobs turn freely. If the shipment has been damaged in transit, notify both the carrier and Keithley Instruments, Inc., at once. Remove packing materials from the instrument case and unpack all accessory items.

CAUTION: Do not attempt to operate a damaged instrument.

c. Do not restrict air circulation in and around the recorder. Ambient operating temperatures must not exceed 120°F. In addition, the instrument should not be positioned close to transformers or conductors carrying high currents.

WARNING: If an earth-ground power source is not available, it is recommended that a separate ground connection be made to the recorder case.

2-2 CONNECTIONS

a. Before making any electrical connections, refer to all of the instructions in this section.

WARNING: Power line voltage is present on rear-panel terminals 1 through 5.

b. Connecting the Model 370 Recorder and a Keithley measuring instrument is convenient and easy. Three separate binding posts are provided on the front of the Model 370 for input-signal and ground connections. The signal to be recorded is applied to the instrument by using the Model 3701 Input Cable which is furnished as a standard accessory. The cable has a connector which mates with the output connector used on most Keithley instruments. No special wiring is needed. In most cases, all that is necessary is to connect thetwo units, turn the amplifier on, and adjust an easily accessible control for full-span recorder deflection.

c. The Model 370 is specially shielded to avoid pickup of extraneous signals. It can operate up to ±500 volts off ground, making it compatible in floating applications with Keithley microvoltmeters and electrometers. The following specific instructions are for connecting the Model 370 Recorder with Keithley electrometers, picoammeters and nanovoltmeters.

d. 1 to 5 volt inputs -- The Model 370 can be connected directly to the output terminals of any Keithley instrument which has a full-scale output between 1 and 5 volts at 1 milliampere.

(1) Connect the instruments with the furnished Model 3701 Input Cable. The Cable has an Amphenol 80-PC2F plug which mates with the output connectors on most Keithley instruments.

(2) Use the Calibration Control (Figure 2) to adjust the Recorder for full-span deflection.

(3) Some Keithley models, such as the Models 601 and 610B Electrometers, can be set for current or voltage outputs. To use the Model 370 Recorder with these instruments, set the Output Control to 1 MA.

e. Inputs greater than 5 volts -- The Model 370 can be connected directly to the output terminals of Keithley instruments which have a full-scale output greater than 5 volts by adding a resistor to the Recorder.

(1) Remove jumper lead and connect the resistor between terminals 12 and 14 on the Model 370 rear panel (see Figure 3).

(2) The resistor value can be between 5 and 9 kilohms, depending upon the input signal to the Recorder and the setting of the Calibration Control. For example, a 9K-ohm resistor will allow input signals up to 15 volts. The resistor can be deposited carbon, wire wound or metal film. Make sure its temperature characteristics are such that it will not change value appreciably when it heats up.

f. In some sensitive Keithley nanovoltmeters and microvoltmeters, an 8Hz beat may appear at the output on the most sensitive ranges in the presence of magnetic fields. The beat can be filtered if it is objectionable by adding a capacitor across terminals 15 and 17 on the rear panel (Figure 3). Note that adding the filter slows the response time. The capacitor should be an electrolytic with a value of approximately 100mfd. Observe proper polarity.

NOTE: Always keep connectors clean and tight to insure good electrical contact.

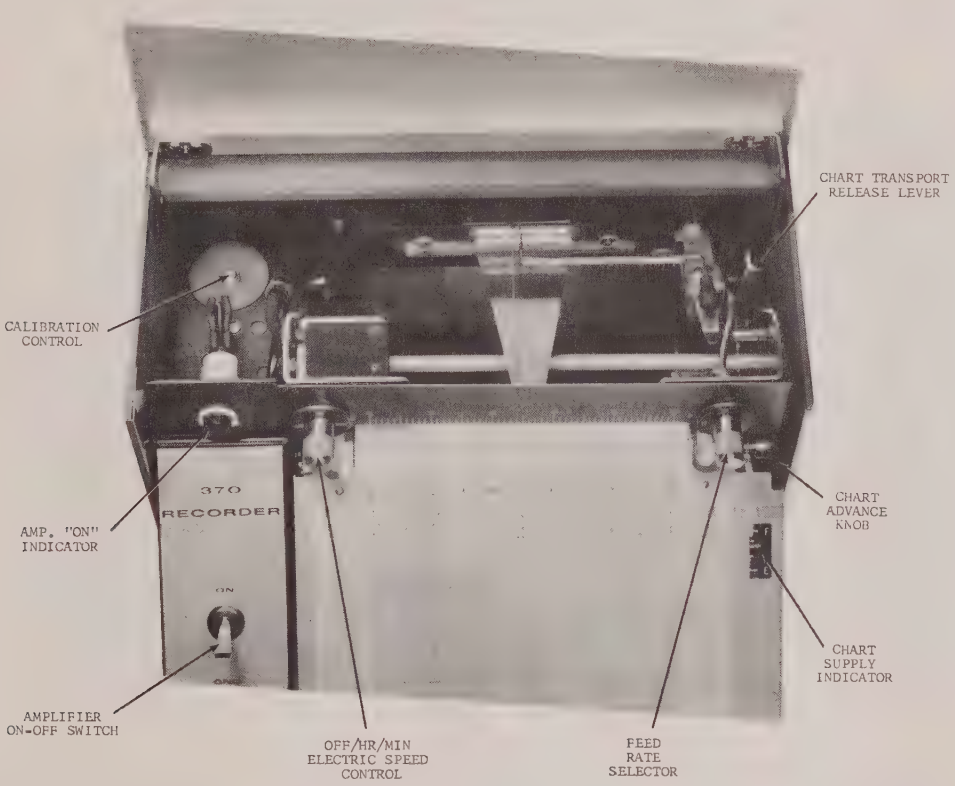


Figure 2. Operating controls on the Model 370 Recorder.

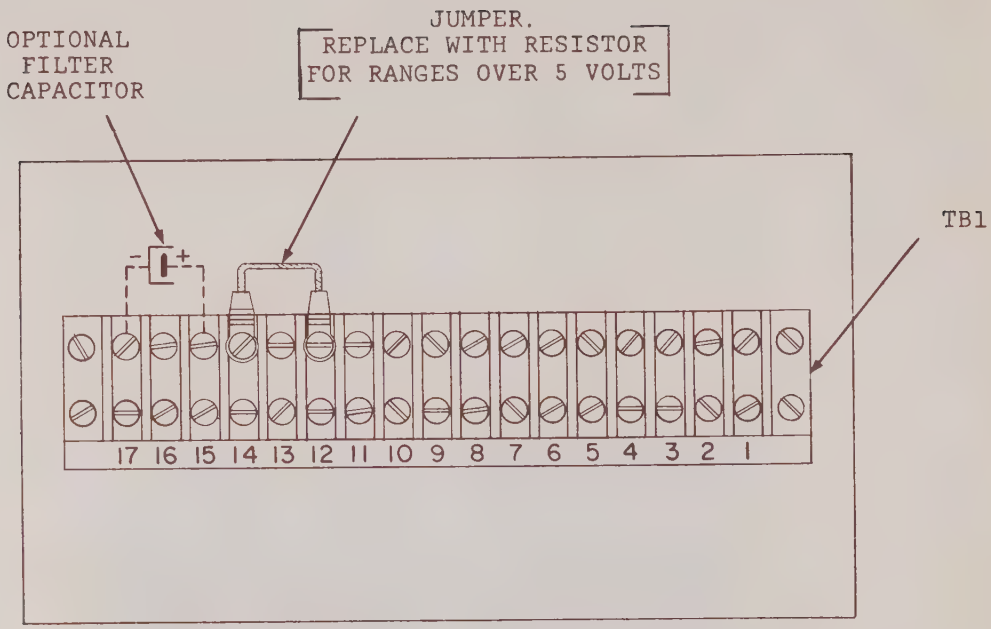


Figure 3. Rear panel of Model 370 with cover plate removed.

2-3 CHARTING PROCEDURES

a. Following are instructions for installing chart paper in the recorder. To maintain guaranteed accuracy and insure optimum performance, always use Keithley Model 3702 precision charts in this instrument. Before preparing the instrument for operation make sure that all packing materials are removed, and that the instrument is resting on a firm flat surface. See that chart-drive power is off. It is also recommended that the measuring element be de-energized. Proceed with the charting steps in the following order --------

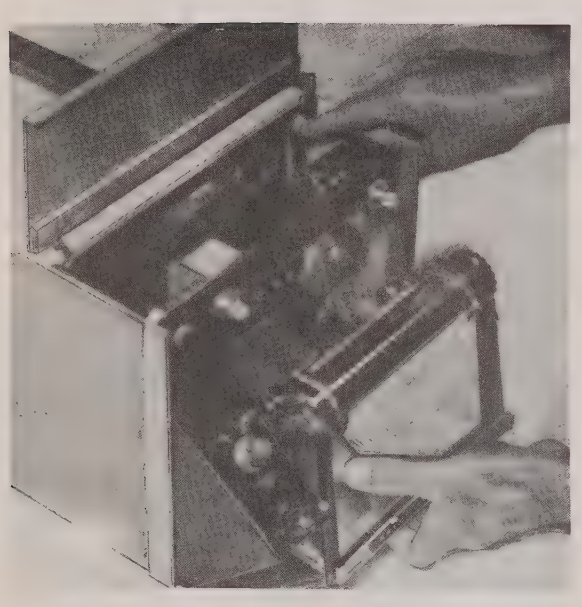


Fig. 4. Raise case lid and permit transport assembly to tilt down by pressing lever on right side of case as shown.

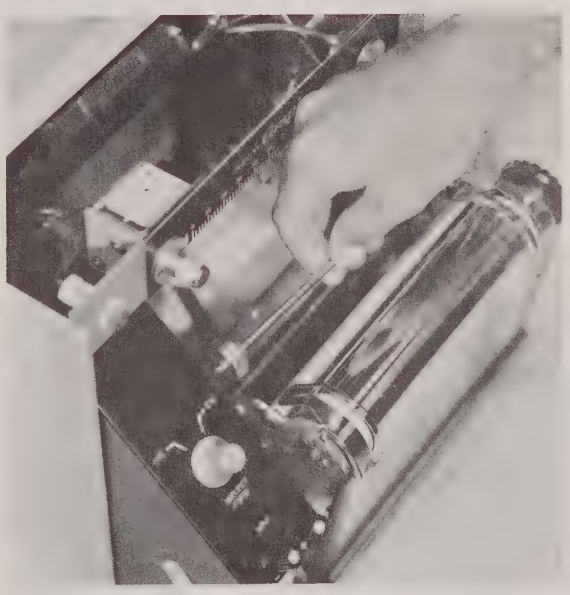


Fig. 5. Remove supply roll arbor by pushing back and lifting straight up. Center paper roll on arbor (elongated perforations to right) and snap loaded arbor back into transport.

Fig. 6. Tear or cut end of paper to "V"; turn up point slightly and feed under hold-down bar and over top of drive roller. Turn time-set knob so roller pins engage chart perforations.

Fig. 7. Swing transport up to operating position. Open door at bottom of transport and remove reroll cylinder by lifting up, then down and out as shown. Keep cylinder straight when removing or installing.

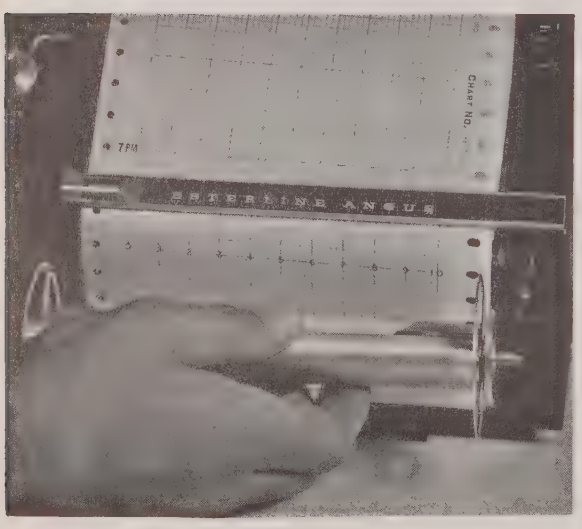


Fig. 8. Holding cylinder with gear end to right, insert chart into slot and slide paper-guide disk on gear end of cylinder outward. Roll several turns on cylinder and slide guide disk inward just to edge of paper.

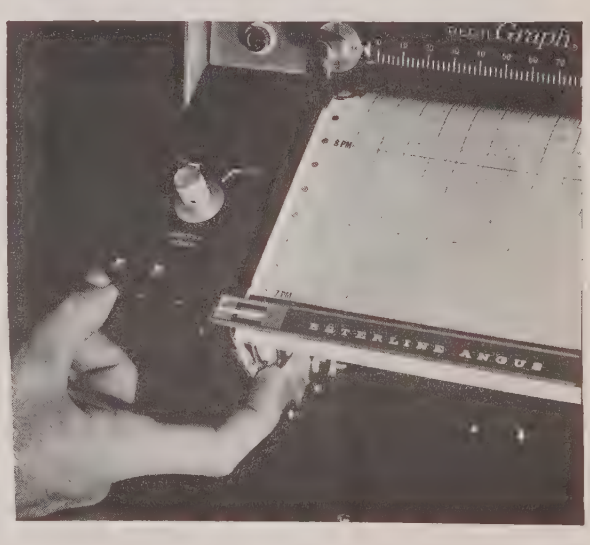


Fig. 9. Snap reroll back into transport. Take up chart slack by rotating disk on left end of reroll cylinder as shown. Turn on chart drive and check operation. Chart may be set to any desired position by turning the time-set knob.

2-4 CHART DRIVE CONTROLS

a. Chart drive controls are located on the scaleplate panel directly above the chart transport assembly. The electric speed control, which may be used to select either hour or minute speeds, is positioned on the left side of the panel. This switch has a three-position sequence of Off-Hour-Minute.

b. The chart drive also has a feed-rate selector switch located at the right end of the scaleplate panel. This switch permits the operator to select any one of five different transmission speeds (or chart feed rates). The control knob is calibrated in inches, and will have a five-position sequence of: .75, 1.5, 3, 6, and 12. The operator may rotate this panel knob in either direction to select the desired rate of feed.

c. To operate the drive, place the knob on the left of the panel in the desired time-rate position (HR or MIN); and set the knob on the right to the desired chart feed rate (in inches). Chart speed may be changed at any time by re-setting either knob with the chart in motion or at rest. To stop the chart paper, rotate the switch on the left to its "OFF" position.

NOTE: See the Maintenance Section for other chart drive adjustments.

2-5 INKING PROCEDURES

a. The following instructions explain how the writing system of the recorder is prepared for operation. The Model 370 features a completely new method of inking; this self-priming system virtually eliminates ink handling and spillage.

b. Only Keithley graphic ink should be used; this writing fluid is especially formulated to satisfy the exacting requirements of recording instruments. Model 3703 disposable plastic cartridges containing 6cc of red ink are available. Each cartridge has a sufficient quantity of ink to complete an entire chart roll. To insure continuous records, always check the ink supply when changing charts. Since ink may begin to thicken at low temperatures, heat must be provided within the recorder if temperatures remain below 20°F.

c. Initial Preparation:

(1) Make sure that all shipping materials have been removed from the case and chassis.

(2) Remove pen assembly from its separate packing box.

CAUTION: The pen staff has a specific configuration for proper recording. DO NOT BEND THIS ELEMENT.

(3) Unpack accessory kit including the following:

2 - ink cartridges (Model 3703)

1 - pen-flusher syringe

1 - pen-point cleaner

(4) Insert new chart (Model 3702) in instrument by following charting procedures.

d. Installing Pen Assembly:

Fig. 10. Rest pen element on flat surface and pierce top of ink cartridge with capillary tube. With holder prongs gripping sides of cartridge, insert tube until holder is flush with top of cartridge.

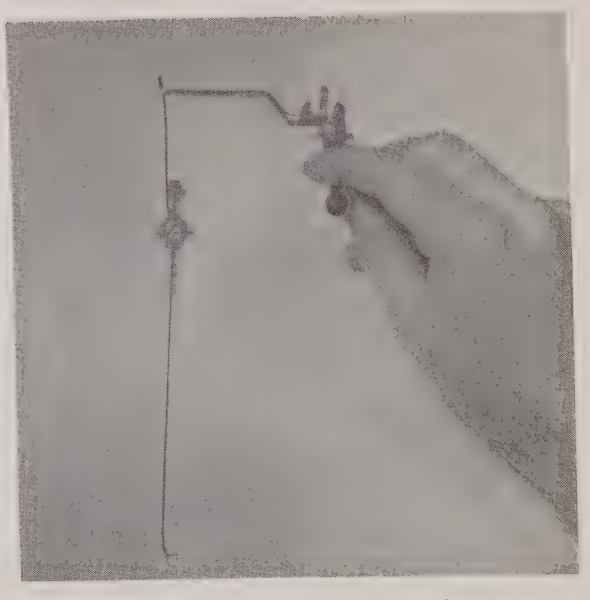


Fig. 11. Holding cartridge assembly with pen suspended by flexible hose, permit pen to swing freely until all twists are removed from hose. Free position of pen staff must be parallel with cartridge holder as shown.

Fig. 12. Seat knife-edge pivot of pen firmly between movement-fork assembly. Insert cartridge bayonets into top of slots in support bracket, and permit cartridge assembly to drop into operating position.

Fig. 13. See that cartridge holder is all the way down in bracket slots. Cover hole in primer bulb, compress bulb, uncover hole, and release. Repeat until ink appears at pen point.

NOTE: To regulate ink flow, loosen screw in cartridge holder and adjust holder up or down as required.

2-6 ZERO ADJUST

a. Zero setting of the pen element must be checked periodically to insure accurate recording. Before attempting this adjustment, however, make certain that no signal is applied to the input terminals and that the pen is full of ink and correctly balanced. If common return of the input circuit is above ground potential, disconnect the input completely. Procedures for balancing the pen element are given in this manual under the Maintenance Section.

CAUTION: If a correct zero setting cannot be obtained, refer to the troubleshooting procedures in the Maintenance Section. DO NOT BEND PEN STAFF.

b. Zeroing Procedure:

(1) Turn on amplifier power switch on front panel. Panel lamp should light.

(2) Open door at bottom of chart transport.

(3) Locate zero adjust lever at base of case.

(4) Move lever laterally and tap lightly on top roller of transport until pen point comes to rest on zero line of chart.

NOTE: Recording errors may be introduced if zero is shifted to a position other than that for which the instrument is designed. The Model 370 is designed for left hand zero.

2-7 CALIBRATION ADJUST

a. To adjust full-span calibration of the recorder, proceed with the following steps:

(1) Connect recorder to output of Keithley indicating instrument which will be monitored by the Model 370.

(2) With no signal applied to the indicating meter, zero the recorder to correspond with the zero indication on the scale of the meter. (Chart should be in motion.)

(3) Apply the signal to be measured to the indicating instrument.

NOTE: A signal which produces 2/3 to full-scale deflection is preferred.

(4) Lift lid on top of recorder case and adjust calibration control (R301) until recorder deflection equals precisely the value obtained on the scale of the indicating instrument. (Chart should be in motion.)

(5) Recheck zero setting, and repeat calibration procedure.

2-8 INSPECTING CHART RECORD

a. The chart record may be inspected at any time during operation by unwinding the paper from the reroll cylinder. With the chart drive in operation, the reroll system functions at all times and will reroll any portion of chart unwound for inspection. If desired, the reroll action may be speeded-up without throwing the chart out of time by holding the time-set knob and manually rotating the disk on either end of the reroll cylinder. If a large portion of chart must be rerolled, the cylinder should be removed and the chart rerolled by hand.

b. Instead of rerolling the chart paper on the reroll cylinder, it may be fed over the writing table and straight out of the instrument. If feeding difficulty is encountered at fast chart speeds, it may be necessary to permit the chart to fall over the edge of a bench or table and attach a weight to the paper. A

five-or six-ounce clamp-on device is sufficient for this purpose. Do not pull or jerk on the chart, as this may either throw it out of time, or disengage it from the pins on the drive roller. The bar at the bottom of the writing table may be used as a tear-off edge by pulling the chart straight up from one side to the other.

c. If continuous records are desired, be sure to check the chart indicator regularly. The indicator is positioned on the right side of the writing table surface. At the top of its scale is found the letter "F" -- indicating a full chart roll; and, at the bottom of the scale is the letter "E" -- indicating a near empty supply roll. In addition to this automatic indicator, a warning will appear near the end of each chart roll which indicates that only a few feet of unused chart remain.

d. To maintain instrument accuracy and to insure optimum performance, only Keithley Model 3702 precision charts should be used with this recorder.

2-9 CHART REMOVAL

a. A rerolled chart may be removed from the instrument by proceeding with the following steps:

(1) Turn off chart drive and open small door at bottom of transport.

(2) Grasp chart on reroll cylinder, lift up, and remove from instrument. Keep roll straight when removing.

(3) Remove gear plug from right end of reroll cylinder.

(4) Slide chart roll from open end of cylinder. If chart is too tightly wound, carefully twist paper roll counter-clockwise as it is being withdrawn from cylinder. Place gear plug back into end of cylinder -- making sure that small key pin on plug engages slot in cylinder.

b. Always keep enough charts on hand to operate the recorder for at least one month. By purchasing in large quantities worthwhile savings can be realized.

c. Keithley charts are currently available in useful lengths of 103 feet. The total running time for a chart will, of course, depend upon the chart speed employed. Chart running times, for various chart speeds, are shown in Table 2-1. All calculations in Table 2-1 take into consideration 3 feet of chart for installation. Charts for hour speeds also allow for the loss of an entire 24-hour period, so that they may always be set to the time of day.

TABLE 2-1

RECORDING TIMETABLE

Selected Chart Speed	Travel Time Per Inch	Continuous Running Time
3/4 In./Hr.	80 Min.	65-2/3 Days
1-1/2 In./Hr.	40 Min.	32-1/3 Days
3 In./Hr.	20 Min.	15-2/3 Days
6 In./Hr.	10 Min.	7-1/3 Days
12 In./Hr.	5 Min.	3-2/3 Days
3/4 In./Min.	80 Sec.	26-2/3 Hours
1-1/2 In./Min.	40 Sec.	13-1/3 Hours
3 In./Min.	20 Sec.	6-2/3 Hours
6 In./Min.	10 Sec.	3-1/3 Hours
12 In./Min.	5 Sec.	1-2/3 Hours

SECTION 3

PRINCIPLE OF OPERATION

3-1 GENERAL

a. The Keithley Model 370 Recorder is designed to graphically record analog information on 6" strip charts with 4-1/2" active recording spans. The chart used has rectilinear coordinates and is linearly calibrated. A pen-and-ink system is employed as a method of writing, and the chart paper is propelled by a variable-speed motor-drive assembly.

b. The measuring and recording system consists of three functional sections -- (1) the Input Amplifier, which matches the source impedance to the instrument; (2) the Meter Movement, which transforms the measured signal into pen deflection; and (3) the Chart Drive mechanism, which moves the chart paper at a selected uniform rate.

c. Each functional section contains only precision components of rugged construction to insure the utmost in both accuracy and reliability. The following discussion will describe each section individually.

3-2 INPUT AMPLIFIER

a. An impedance matching amplifier is employed in the Model 370 to condition the input signal. The block diagram in Figure 14 illustrates how the amplifier functions in the measuring system.

b. This transistorized module reduces the effective input resistance of the recorder and stabilizes response time by causing the measuring element to appear critically damped regardless of external circuit conditions.

c. Matching is accomplished by making use of the input and output impedance characteristics of a current-sensitive transistor amplifier. This linear amplifier has a non-polarized input and a unity-gain applification factor. A complete schematic of the amplifier appears in the Maintenance Section of this manual.

d. Calibration control, R301, is connected in series with the positive input lead to the amplifier. The operator may use this control to vary the input signal between 1- and 5- volts for a desired full-span calibration. For signals larger than 5 volts, resistors are used on the rear terminals.

e. Due to its compact solid-state construction, the matching network and its power supply is self-contained within the recorder case. The amplifier is made operative by merely connecting the signal and actuating the power switch on the front panel of the recorder. The lamp on the front panel will indicate whenever the amplifier is energized.

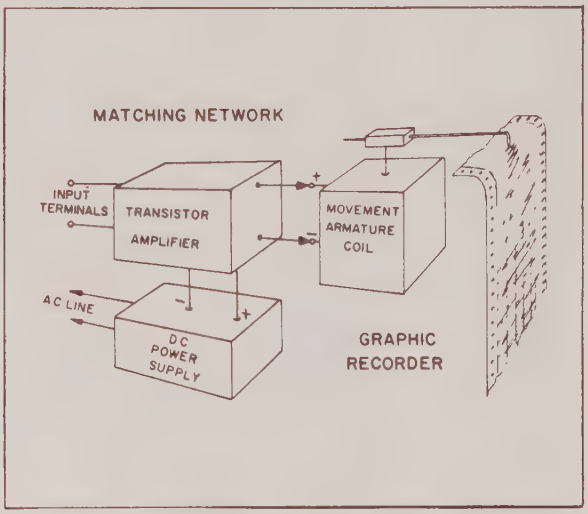


Figure 14. Block diagram of Amplifier showing connections to recorder movement.

3-3 METER MOVEMENT

a. The d'Arsonval-type meter movement employed in this recorder features an Esterline Angus "RectiGRAPH" motion translator for rectilinear recording. This permanent-magnet, moving-coil assembly consists of an armature coil suspended in a fixed magnetic field which is formed by a center-core magnet and two large, u-shaped, side magnets.

b. The armature coil is wound on a metal frame which is supported at both ends by jeweled pivots so that it is free to turn. As current flows in the armature, an electro-magnetic field is built up around the coil; this field automatically attempts to move itself out of the fixed field, torque is developed, and the armature turns on its axis.

c. Rotation of the coil is opposed by a pair of counter-wound spiral springs which are connected to the lower part of the armature staff. The springs also return the coil to a fixed zero position when no current is flowing. The degree of rotation depends directly upon the magnitude of current flowing in the armature coil.

d. In addition, the movement has an inherent damping characteristic resulting from eddy currents induced in the moving-coil frame. These currents produce a "bucking" magnetic field that tends to minimize overshoot and oscillation.

e. Rotating motion of the coil is converted to rectilinear recordings through the use of a special motion translator. As shown in Figure 15, this all-mechanical device actuates the writing pen without the use of gears, slidewires, or electrical transducers.

f. The "RectiGRAPH" translator functions as follows: A driving arm, which is attached to the armature staff, causes pivotal pulley A to swing in an arc as indicated by the small arrows in Figure 15. Flexible belt B is fastened to one point on pulley A, and also to one point on fixed drum C. As pulley A swings to either side, belt B wraps around drum C, and thus forces pulley A to rotate on its center pivot. Since the pen element is attached to pulley A, the pen point will follow a straight line across the chart.

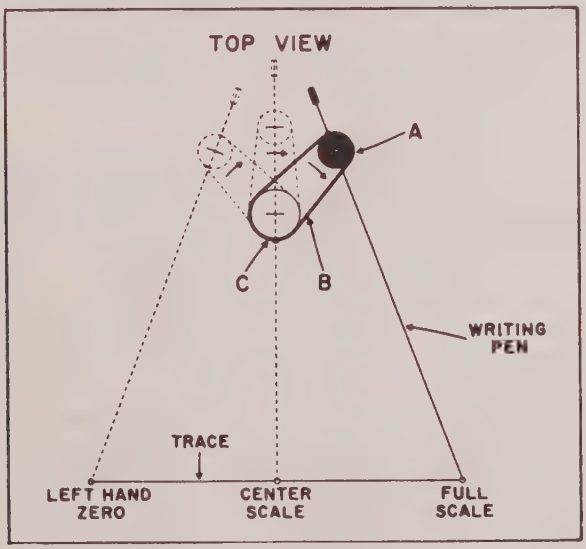


Figure 15. Operational diagram of the RectiGRAPH motion translator which mounts on top of the meter movement.

3-4 CHART DRIVE

a. To produce useful graphic records, a recording instrument must not only incorporate a precision measuring element but also an accurate and reliable chart-propelling mechanism. The chart drive must have enough power to unwind, propel, and rewind the chart paper; and, like a fine watch, it must also function consistently under various environmental conditions. Esterline Angus chart drives have been meeting these rigid requirements for over half a century.

b. In addition to accuracy and reliability, the Model 370 chart drive is designed with versatility and portability in mind. "Up-front" controls, a tilt-down transport, and slanted writing table are some of the convenient features found in this new bench model. The chart drive also has provisions for selecting different chart speeds without manually changing gears.

c. The chart drive is an electro-mechanical device that converts electrical energy into linear physical motion through the use of a motor power source and various gear assemblies. The block diagram of Figure 16 illustrates an entire chart drive system.

d. The motor drive assembly (Figure 16) consists of a synchronous motor and reduction gear head. The synchronous motor must be operated from a frequency-regulated source of AC power. The gear head provides a 60-to-1 speed change. When this feature is used, the operator may select either hour or minute speeds from a front-panel knob.

e. The output shaft of the gear head powers the chart drive transmission. In the transmission, speed is varied by a unique system of cam-operated gears and over-running clutches. Chart feed rates are manually selected by the feed-rate selector located on the front panel. The output shaft of the transmission is always energized and therefore "mesh-time" is negligible, even at slow speeds.

f. Thus far, we have discussed only those components of the chart-driving mechanism which are physically positioned at the rear of the recorder chassis. Since the chart transport assembly is found on the front of the chassis, a special drive coupling is employed. The driving mechanism is coupled to the chart transport by a chain and sprocket arrangement that maintains constant speed and accurate timing throughout the system.

g. A precision gear train in the transport assembly unwinds the chart paper from a supply roll, propels it over a drive roller and rewinds it on a reroll arbor. The drive roller has a number of formed pins at each end which engage marginal perforations in the paper and feeds the chart under the writing element smoothly and at a constant rate. A time-set knob is also provided on the right end of the drive roller for manually advancing the chart paper and setting it to time. In addition, an over-running clutch in the reroll assembly maintains proper tension on the chart paper at all times.

h. The transport assembly incorporates a chart-supply indicator. This small gage tells the operator at a glance the amount of chart paper remaining on the supply roll. Reloading is made easy by a special tilt-down transport.

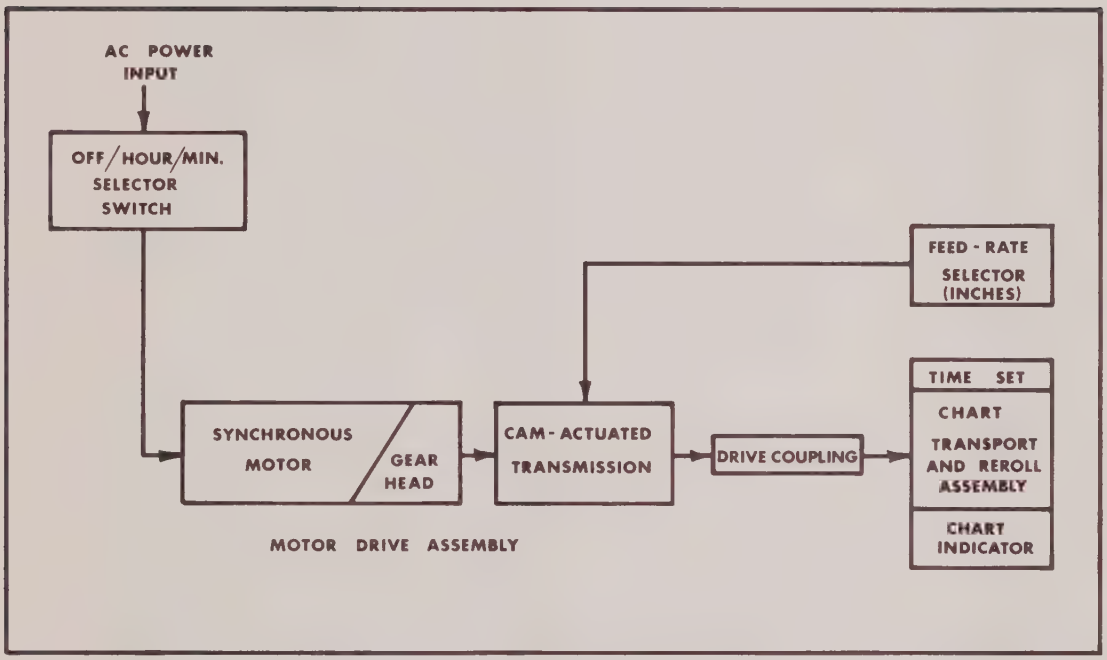


Figure 16. Block diagram of Chart-Drive system for Model 370

SECTION 4

MAINTENANCE INSTRUCTIONS

4-1 GENERAL

a. The Keithley Model 370 Recorder is of sturdy construction and is designed for long trouble-free operation. Nevertheless, it should receive the care afforded any precision piece of equipment to extend its useful life. In the few cases where trouble may occur, it is recommended that the entire instrument be returned to the factory, rather than to attempt any major repairs in the field. Should adjustment or minor service become necessary in the field, refer to the following procedures:

> WARNING: Recorders connected to electrical circuits may be hazardous. To prevent accidental shock, always remove power from the instrument before disassembling or servicing.

4-2 INKING SYSTEM

a. To maintain proper inking, the ink supply and pen element must be inspected regularly. A new ink cartridge should be installed whenever needed, and the pen point kept free from dirt, lint, and dried ink at all times.

b. The mounting height of the ink cartridge is made adjustable so that the operator may vary the liquid head in the capillary system. If the inking pen produces a weak trace or tends to skip, the cartridge should be raised; on the other hand if the pen tends to bleed on the chart, the cartridge should be lowered. For optimum performance, the pen and its feeder-tube assembly should also be cleaned periodically. This may be accomplished by forcing water through the assembly using the pen-flusher syringe.

c. Intermittent writing or a tendency of the ink to spread on the chart paper are indications that the system should be cleaned. Intervals for cleaning will depend upon the nature of instrument operation. If records are obtained with large and frequent excursions of the pen, or at relatively fast chart speeds, ink will flow rapidly and there will be little chance of the system clogging. If the instrument has long idle periods, on the other hand, it may be necessary to clean the system after each use.

d. If the pen point becomes clogged, it may be re-opened by using the pen-point cleaner supplied. Work the cleaner wire in and out of the pen point, flush the element with water, and check operation.

CAUTION: Do not bend pen element or twist flexible feeder hose.

e. Should the flexible hose become inadvertently disconnected from the feeder-tube assembly or from the pen element, it can be easily replaced. The free-swinging position of the pen staff, however, must always be parallel to the cartridge holder as illustrated in Figure 11.

4-3 ZERO ADJUST

a. Although the Model 370 recorder is properly adjusted before leaving the factory, a zero adjust is provided on the chassis for shifting the zero reference position of the pen. The recommended method for adjusting zero is given under Operating Instruction in this manual.

4-4 PEN BALANCE

a. Adjustable weights are provided on the rear of the pen staff for balancing the element. To perform this adjustment, see that the pen is full of ink and proceed with the following steps:

(1) Remove scaleplate from front of instrument.

(2) Carefully remove pen element from fork assembly. Do not place strain on feeder hose.

(3) Loosen back nut on pen staff and turn front nut forward or backward as required for balance. Weights will remain in position when screwed tightly against each other.

(4) After weights are adjusted, replace pen element and scaleplate and check operation.

b. Pen balance should be such that the pen point bounces up from the chart slightly when the top roller of the chart transport is tapped with one finger. If maximum response speed is desired, pen-point pressure must be no greater than necessary to produce satisfactory inking.

4-5 CALIBRATION

a. Instrument calibration should be checked against a known-accurate standard. If recording errors exceed the accuracy limits specified for the overall system, follow the service procedures given under "Troubleshooting". If difficulties persist, return the instrument to the factory for recalibration.

4-6 CHART DRIVE ADJUSTMENTS

a. Although the chart drive employed in the Model 370 is carefully adjusted for standard operation before leaving the factory, certain field adjustments are made possible to satisfy special applications and as a preventative maintenance measure. These adjustments are as follows:

b. Chart Guides -- The paper guides located on top of the drive roller are properly adjusted at the factory and will not normally require attention in the field. If the drive has been subjected to rough handling or has been disassembled in the field, readjustment of the guides may be necessary. The correct position of the chart guides is evident when there is no tendency of the paper to be depressed into the grooves of the drive roller.

c. The turned-down edge "A", Figure 17, should follow the contour of the drive roller, but allow enough clearance so that there is no drag on the paper. It may be necessary to loosen screws "B" (2 per guide), in order to facilitate this adjustment.

d. Drive Roller -- The drive roller retainer, Figure 17, exerts an exact amount of bearing pressure to limit roller end-shake; thus fixing the position of the roller and eliminating lateral motion of the chart paper.

e. End-shake is varied by loosening or tightening screw "X" (Figure 17). A correct setting is obtained when the small gap between the brass bearing and the plastic end piece of the roller (point "P") remains constant as the roller drum is whirled by hand. If this screw is too loose, the roller will drift back and forth; and if too tight, the roller will not spin freely. Although this adjustment has been correctly set at the factory, readjustment may be necessary if screw "X" has been inadvertently moved.

f. Reroll Clutch -- For optimum chart drive operation, the reroll system must apply a regulated amount of tension on the chart paper at all times. To supply this tension, the reroll cylinder contains a small clutch as part of its removable gear assembly. Clutch tension is adjusted by withdrawing this assembly from the reroll cylinder and turning the adjustment nut as required. See Figure 18.

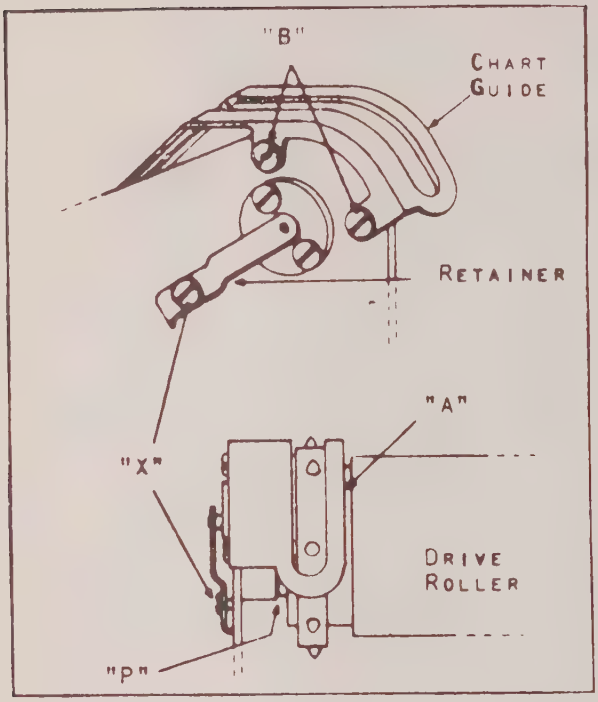


Figure 17. Chart Guide and Retainer Adjustments.

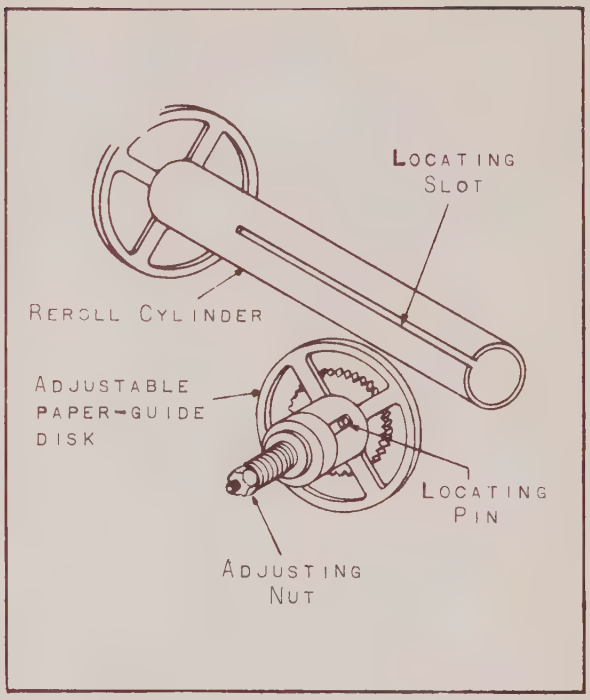


Figure 18. Reroll Clutch Adjustment.

g. If clutch tension is too great, the chart paper may start to wrinkle as it leaves the drive roller. In extreme cases, the paper may even tear or skip pins on the drive roller. If there is not enough tension, the chart paper may tend to sag and not wrap properly on the reroll cylinder. These conditions will not exist when the clutch is correctly adjusted.

NOTE: Do not attempt to adjust the clutch unless reroll trouble has been traced to this possible source.

h. Drive Chain -- The chain and sprocket mechanism on the right side of the instrument chassis must be correctly installed for reliable operation of the chart transport. Recommended orientation and tension of the chain are shown in Figure 19. Note direction of chain links and the slight amount of chain sag under load. Chain tension may be adjusted by loosening the mounting screws of the transmission components and moving them backward or forward as required. This adjustment will normally entail considerable disassembly and should not be performed unless absolutely necessary.

NOTE: Do not lubricate the chart drive chain.

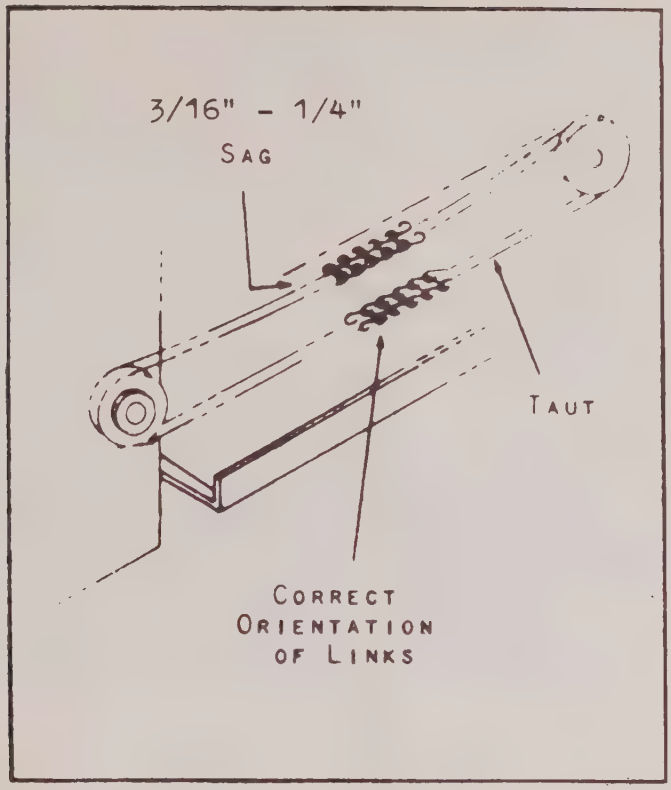


Figure 19. Drive Chain Positioning.

4-7 DISASSEMBLY

WARNING: To prevent accidental shock, always remove power from the instrument before disassembling or servicing.

a. Access to chassis components is made possible by a detachable top section of the portable case. Before removing this section, however, always see that the power cord is disconnected and that other high potentials are removed from input terminals.

b. The top section of the case may be taken off by removing 3 screws from each side of the lower baseplate. Lift the section from the chassis as pictured in Figure 20. Once the chassis is exposed, all modular components making up the recorder are accessible for inspection or servicing.

CAUTION: Never remove the armature from the permanent magnet structure unless means are available to recharge the magnet-armature assembly and recalibrate the measuring element.

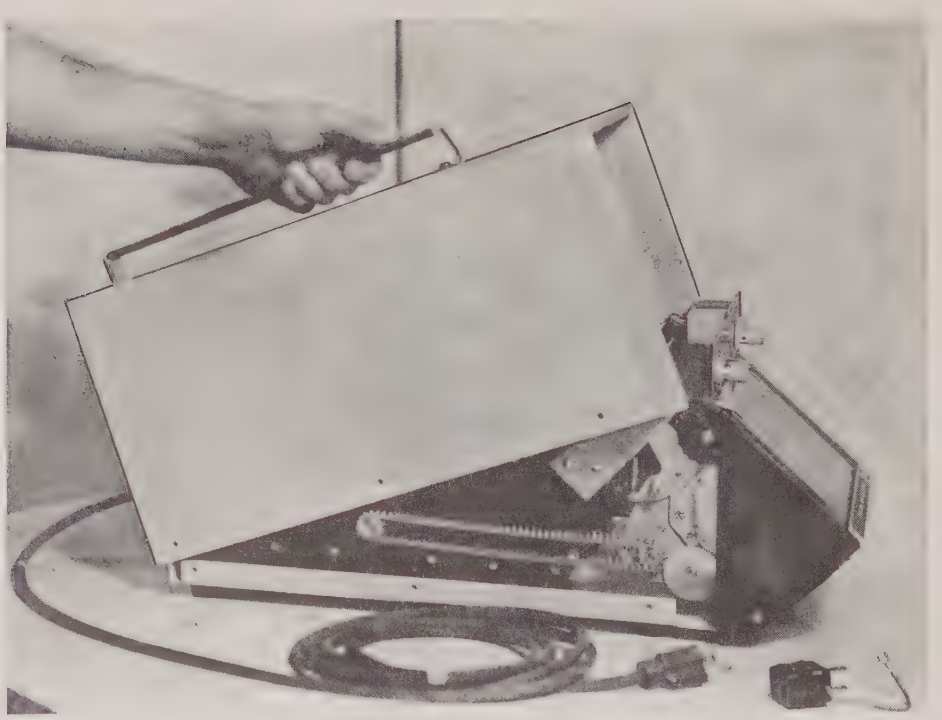


Figure 20. With top of case removed, all modular chassis components are accessible for inspection or servicing.

c. To remove the chart transport assembly from the instrument, lower the transport assembly to the chart-loading position. Carefully lift straight up on the transport and remove from front of recorder. To reassemble, reverse the above procedures being careful to mesh the gears properly without force. Further disassembly of the chart drive is not recommended for field maintenance.

4-8 CLEANING AND LUBRICATION

a. The entire recording instrument should be cleaned at regular intervals depending upon environmental conditions. A soft-bristled brush, vacuum, or low-pressure air gun may be used to dis-lodge foreign particles and dirt from most of the assemblies. If ink or other liquids are accidentally spilled on surfaces of the recorder, clean the unit immediately using a soft cloth or paper towel moistened with water.

b. All bearings of the chart drive system are self-lubricating and will not require relubrication under normal operating and environmental conditions. If bearing lubrication is deemed necessary, use EA 40 oil, obtainable from Esterline Angus Instrument Company, Inc.

c. Operating temperatures outside the range of 20° to 100°F will require special lubrication (consult factory). Do not oil ratchets and pawls; they operate better when dry. When oiling exposed bearing surfaces, it is well to remember that too much lubrication is almost as bad as too little.

4-9 TROUBLESHOOTING

a. If it is suspected that the recorder is not functioning properly, the following service procedures are recommended:

(1) See that pen is seated properly in pen fork and check zero setting as described under "Zero Adjust". If instrument will not zero, check pen balance adjustment.

(2) Check all external connections and see that they are clean and tight. Check internal connections at rear panel.

(3) See that instrument is not positioned near a strong magnetic field or subjected to other adverse environments.

(4) Check freedom of movement by drawing pen across chart. Do not place strain on pen staff, but expose chassis and actuate pen by carefully swinging lower bearing assembly located at the rear of the motion translator mechanism.

(5) If movement is erratic, examine clearances of pen staff and flexible hose. Hose must not be twisted or kinked.

(6) Check to see that amplifier is getting power (panel lamp must be on).

(7) Measure signal output of amplifier at meter terminals. If abnormal, replace or service amplifier PC board.

(8) If steps 1 through 7 fail to isolate trouble, remove pen-element and ink-cartridge assembly and follow disassembly procedures. The complete movement may be taken out by removing two screws from each side of the chassis.

(9) Carefully clean movement assembly, chassis, and case. Look for physical damage and inspect wiring.

CAUTION: Do not damage motion translator mechanism.

(10) Examine coil leads and control springs of movement by turning armature through all positions. If coil leads are burned off or control springs are damaged, return instrument to factory for service.

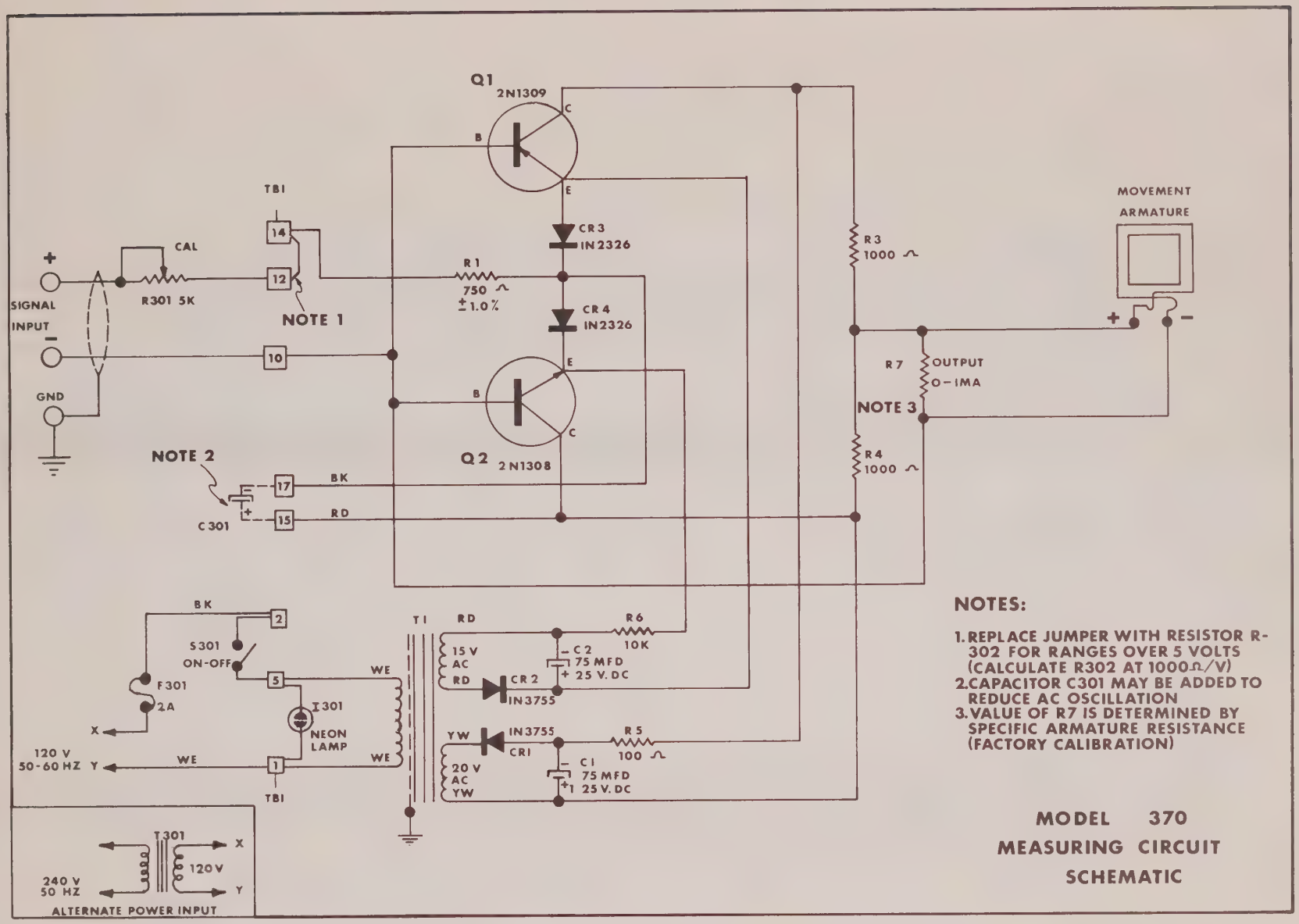
(11) Using bridge or portable ohmmeter, check DC resistance of components in measuring circuit. If values differ markedly from those specified, replace faulty components or return instrument to factory.

CAUTION: Do not attempt to adjust the motion translator assembly. This precision mechanism must be serviced at only the factory or by its authorized representatives.

4-10 REPLACEMENT PARTS

a. All parts for the Model 370 recorder are available from Keithley Instruments, Inc. When ordering parts, always give part numbers and the instrument serial number. Refer to the assembly drawings in this manual for parts identification.

b. When ordering parts or subassemblies by part numbers listed on the assembly drawings, insert the letters "EA" in front of each part number so as to indicate our supplier and avoid delay.

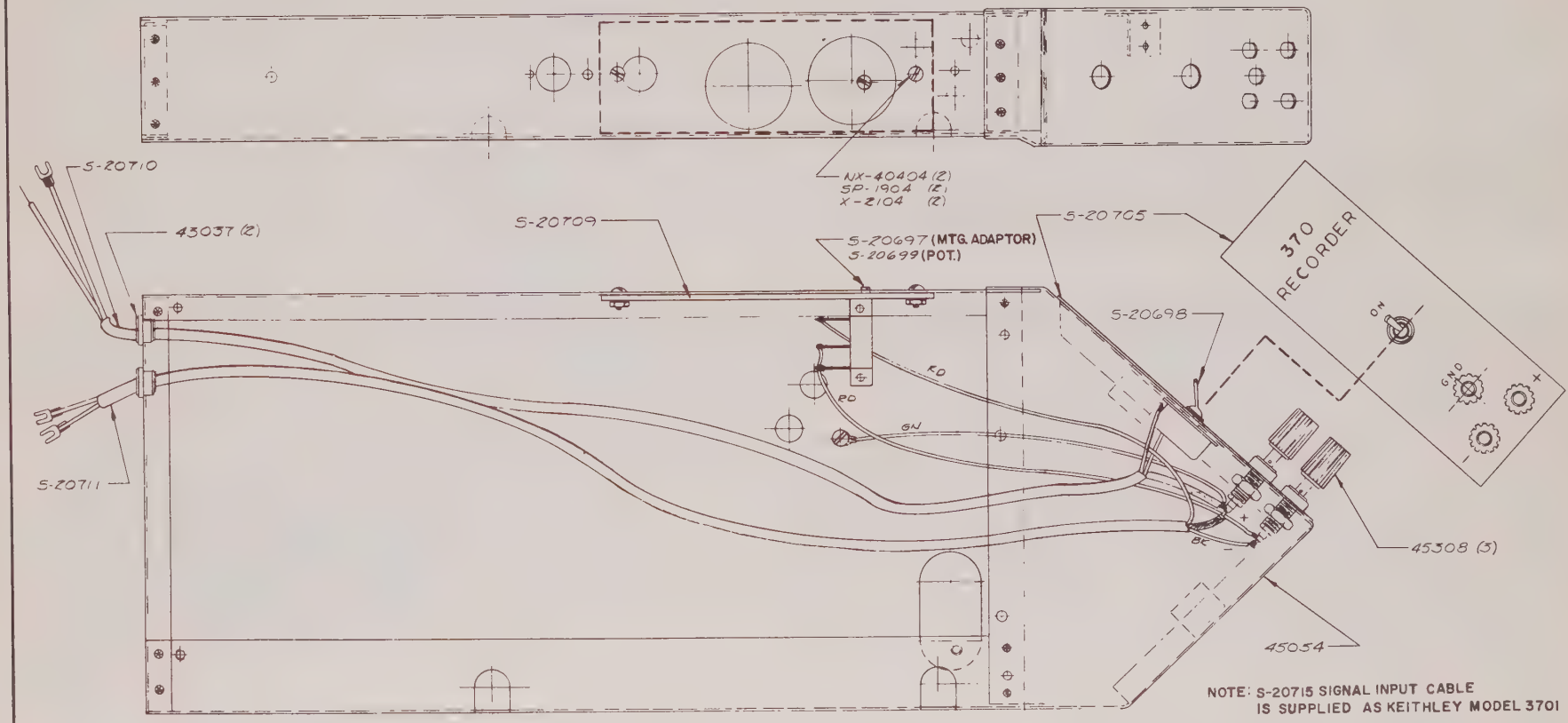


NOTES:

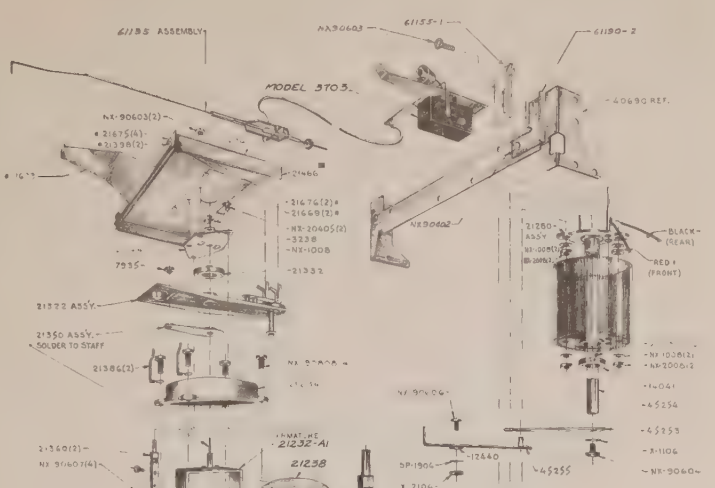
1. REPLACE JUMPER WITH RESISTOR R-302 FOR RANGES OVER 5 VOLTS (CALCULATE R302 AT 1000Ω/V)
2. CAPACITOR C301 MAY BE ADDED TO REDUCE AC OSCILLATION
3. VALUE OF R7 IS DETERMINED BY SPECIFIC ARMATURE RESISTANCE (FACTORY CALIBRATION)

MODEL 370
MEASURING CIRCUIT
SCHEMATIC

NOTE: WHEN ORDERING PARTS OR SUBASSEMBLIES BY PART NUMBERS LISTED ON THIS DRAWING, INSERT THE LETTERS "EA" IN FRONT OF EACH PART NUMBER SO AS TO INDICATE OUR SUPPLIER AND AVOID DELAY.



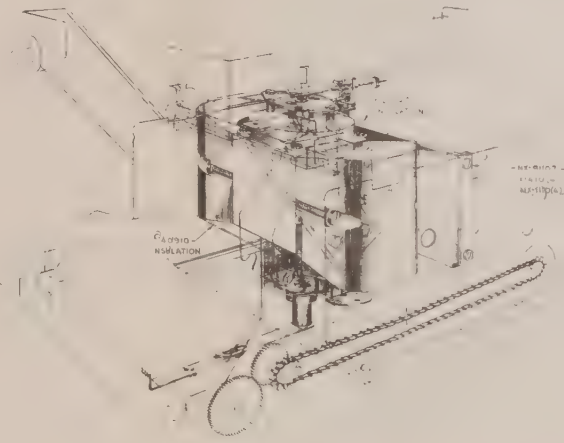
CONTROL BOX ASSEMBLY
FOR KEITHLEY MODEL 370 RECORDER



BAND ASSEMBLY

NOTE: WHEN ORDERING PARTS [illegible] NUMBERS LISTED ON THIS DRAWING, INSERT THE LETTER "A" IN FRONT OF EACH PART NUMBER SO AS TO [illegible] OUR SUPPLIER AND AVOID DELAY.

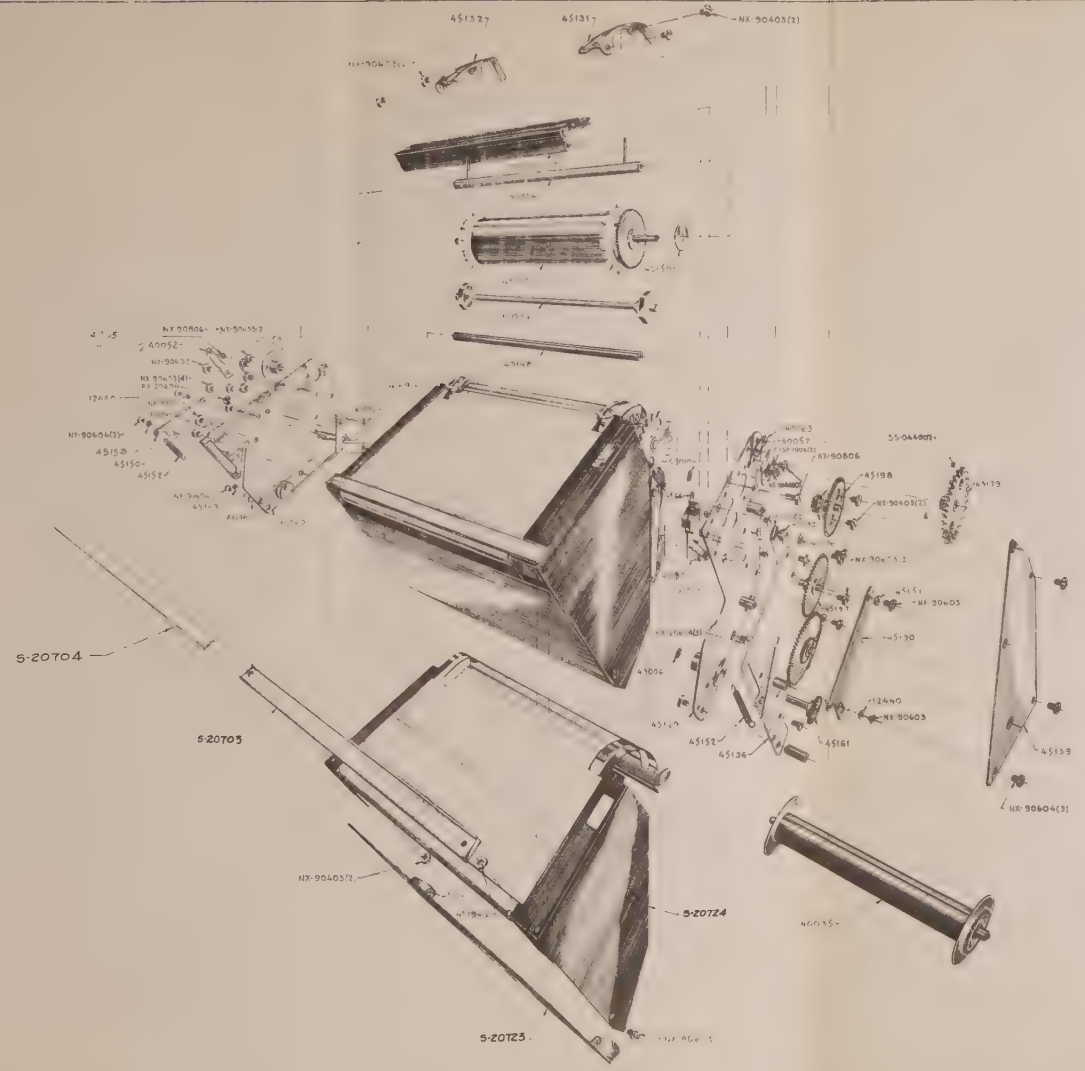
FRONT
ARMATURE COIL LEADS



ASSEMBLY

MEASURING ELEMENT ASSEMBLY
FOR KEITHLEY MODEL 370 RECORDER

45250M

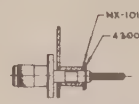


NOTE: WHEN ORDERING PARTS OR SUBASSEMBLIES BY PART NUMBERS LISTED ON THIS DRAWING, INSERT THE LETTERS EA IN FRONT OF EACH PART NUMBER SO AS TO INDICATE OUR SUPPLIER AND AVOID DELAY.

CHART TRANSPORT ASSEMBLY

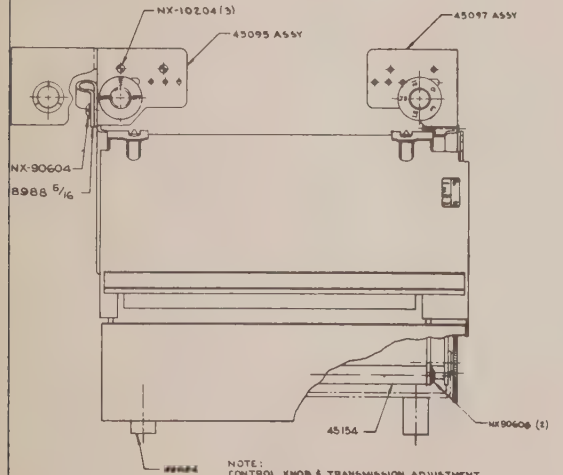
FOR KEITHLY MODEL 370 RECORDER

45120 M

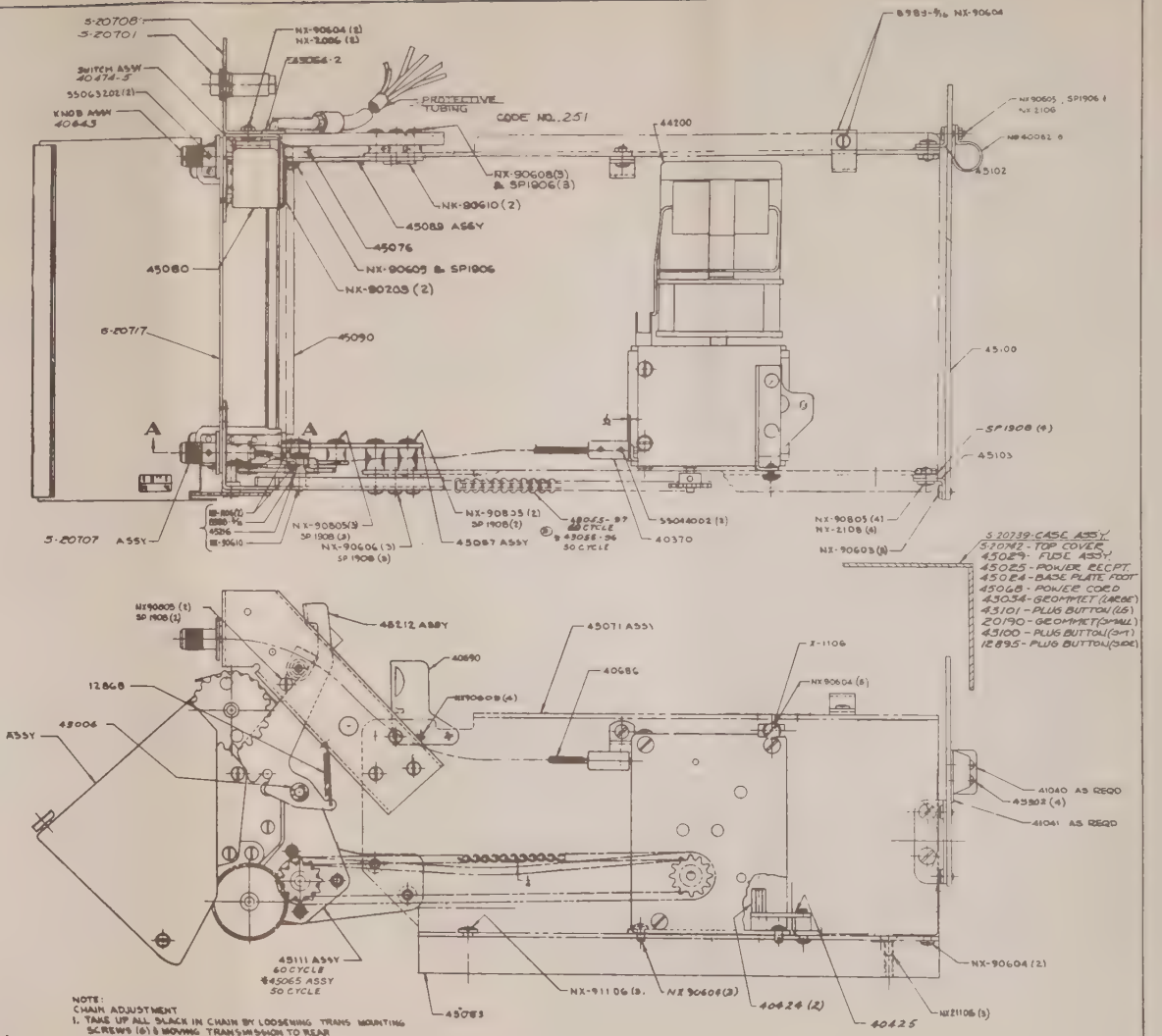


SECTION A-A
MULTI-SPEED TRANSMISSION

NOTE: WHEN ORDERING PARTS OR SUBASSEMBLIES BY PART NUMBERS LISTED ON THIS DRAWING, INSERT THE LETTERS "EA" IN FRONT OF EACH PART NUMBER SO AS TO INDICATE OUR SUPPLIER AND AVOID DELAY.



NOTE:
CONTROL KNOB & TRANSMISSION ADJUSTMENT
1. PLACE CONTROL KNOB (5-20707) ON CONTROL SHAFT (40686) ALIGNING SET SCREW WITH FLAT ON SHAFT
2. ADJUST KNOB LATERALLY ON SHAFT, SO KNOB & SHAFT ROTATE FREELY & DETENT PIN MAKES FIRM CONTACT WITH DETENTS IN BACK OF KNOB FLANGE TIGHTEN SET SCREW
3. WITH TRANS. CAM (CONTROL KNOB SET ON 1.5 SPEED, PLACE COUPLING (40710) ON TRANS. CONTROL SHAFT & PLACE CABLE END IN 'D' HOLE OF COUPLING
4. POSITION COUPLING WITHIN APPROX. 1/32 OF TRANS (AS SHOWN) & TIGHTEN SET SCREWS
5. PAINT SET SCREW ON TRANSMISSION END OF COUPLING WITH RED LACQUER

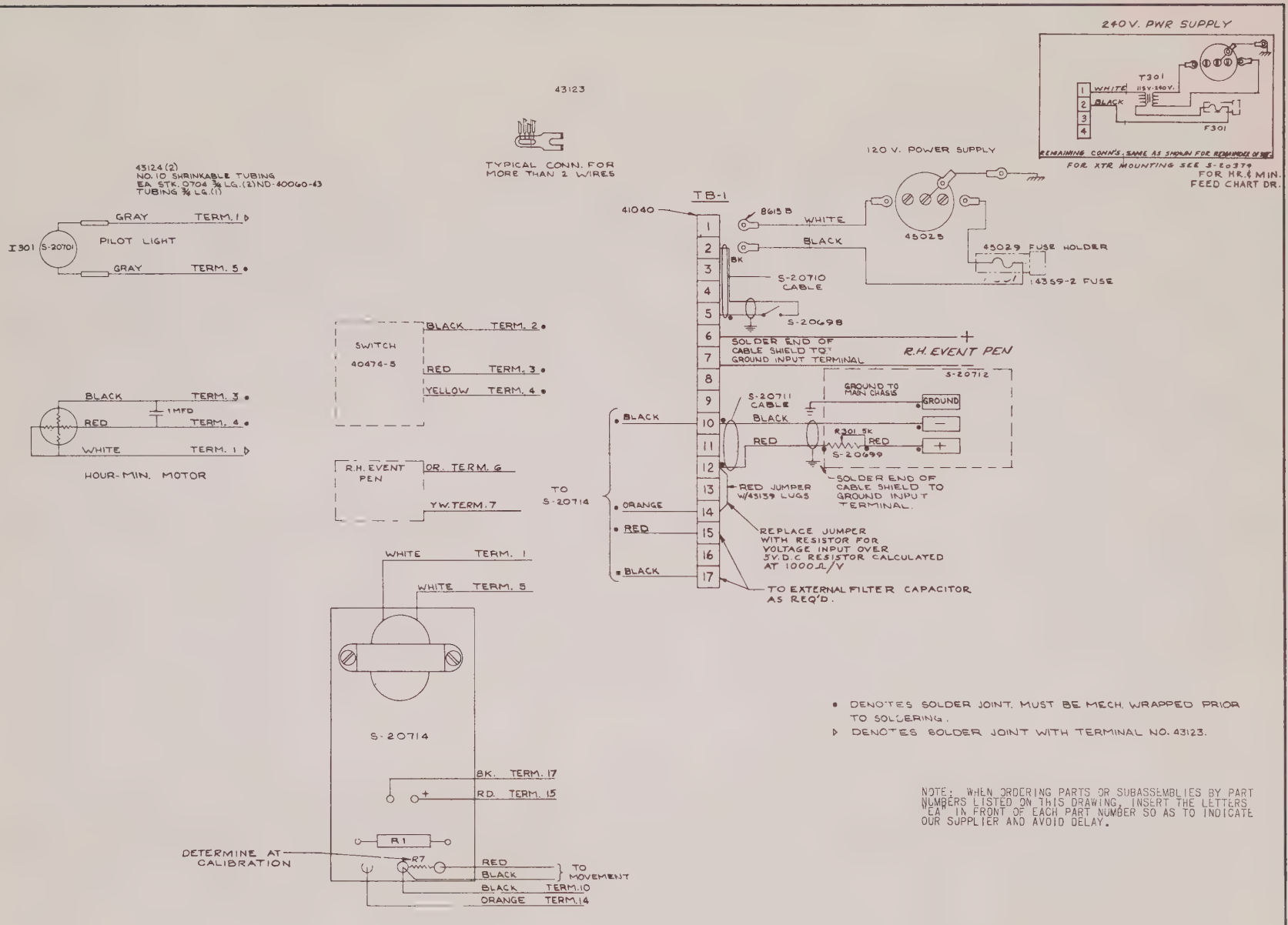


NOTE:
CHAIN ADJUSTMENT
1. TAKE UP ALL SLACK IN CHAIN BY LOOSENING TRANS MOUNTING SCREWS (6) & MOVING TRANSMISSION TO REAR
2. SNUG UP TRANS. MOUNTING SCREWS, BUT DO NOT TIGHTEN
3. SET SLACK IN CHAIN BY TAPPING TRANS FORWARD & USING GAGE NO. TO OBTAIN APPROX. 1/8 SLACK (AS SHOWN)
4. TIGHTEN TRANS. MOUNTING SCREWS

CHART DRIVE, CHASSIS AND CASE ASSEMBLY
FOR KEITHLEY MODEL
370 RECORDER

* COMPLETE CHASSIS ASSEMBLY FOR 60 CYCLE OPERATION IS NO. 45070-2-60

45070-2M



• DENOTES SOLDER JOINT. MUST BE MECH. WRAPPED PRIOR TO SOLDERING.

▷ DENOTES SOLDER JOINT WITH TERMINAL NO. 43123.

NOTE: WHEN ORDERING PARTS OR SUBASSEMBLIES BY PART NUMBERS LISTED ON THIS DRAWING, INSERT THE LETTERS "EA" IN FRONT OF EACH PART NUMBER SO AS TO INDICATE OUR SUPPLIER AND AVOID DELAY.

WIRING DIAGRAM FOR KEITHLEY MODEL 307 RECORDER

S-9691M

MODEL 3704R

EVENT PEN ATTACHMENT

1-1 DESCRIPTION

a. An event pen is designed to graphically record on the side portion of the chart paper used in the Keithley Model 370 recorder. The record produced is an "on-off" indication showing time of occurrence and duration of events normally related to the analog record.

b. The event pen is actuated by a small electromagnet assembly. When voltage is applied to the circuit, the pen is displaced toward the outer edge of the chart paper; the pen will return to a normal "off" position when voltage is interrupted. When this attachment is ordered, the electromagnet coil will be connected to two terminals on the rear terminal block. These terminals are accessible by removing a cover plate from the rear of the instrument. Electrical ratings and terminal connections are specified on the Terminal Code Plate, which is also found on the rear of the instrument. The right-hand event pen will be identified as "R.H. Pen".

c. Use only Keithley graphic ink; this writing fluid is especially formulated to satisfy the exacting requirements of recording instruments. Disposable ink cartridges are supplied with each event pen; these plastic units are also available upon order. To insure continuous records, always check the ink supply when changing charts. Ink may begin to thicken at low temperatures and therefore heat must be provided within the recorder if temperatures remain below 20°F.

1-2 OPERATING PROCEDURES

(1) Unpack event pen equipment and make sure that all shipping materials have been removed from the recorder.

(2) Make electrical connections to the electromagnet coil (See Terminal Code Plate.)

(3) Pierce recessed end of ink cartridge with metal tube of cartridge holder. Insert tube until holder is flush with top of cartridge.

(4) Remove twists from rubber hose and install pen and cartridge assembly in mounting bracket of recorder. (See that pen tail engages lever arm of electromagnet).

(5) Cover hole in end of primer bulb, compress bulb, uncover hole, and release. Repeat until ink appears at pen point.

(6) Check performance by starting chart drive and energizing the electromagnet.

1-3 ADJUSTMENTS

a. When it is desired to synchronize the event-pen record with the analog record, the point of the event pen must rest on the chart directly in line with the point of the analog pen. With a stroke of approximately 3/32", the event pen should also record on that portion of chart between the side paper guide and the adjacent edge of the analog ruling on the chart. If an event pen is out of alignment, proceed with the following steps:

(1) Place analog and event pens in correct operating position.

(2) Position chart so that analog pen point is resting directly upon horizontal time line of chart.

(3) Loosen adjustment screw on top of cartridge bracket. (See assembly drawing.)

(4) Adjust event-pen element until desired alignment is achieved.

(5) Hold pen element in position and tighten adjustment screw.

b. Vertical positioning of the event pen may be corrected by carefully bending the element. The pen point should rest on the chart paper with the top of the electromagnet arm not touching the pen tail.

1-4 MAINTENANCE.

a. A new ink cartridge should be installed whenever needed, and the pen point kept free of lint, dirt, and dried ink at all times. The event pen should be cleaned periodically by removing the ink cartridge and forcing water through the assembly using the pen-flusher syringe. If the pen point becomes clogged, it may be re-opened by using the pen-point cleaner supplied. Work the cleaner wire in and out of the pen point and flush the element with clear water.

b. When ordering event pen parts, always give part numbers plus the model and serial number of the recorder using the accessory. Also specify voltage rating. Refer to the assembly drawing supplied for the field installation of this accessory.

DC RATINGS

VOLTAGE RANGE	RIGHT HAND ASSEMBLY NO.	COIL NO.	SERIES RESISTANCE TUBE OHMS
1.55-2.56	41204-N	17010-N	
2.0-3.36	41204-M	17010-M	
2.5-4.0	41204-L	17010-L	
3.1-5.1	41204-K	17010-K	
4.1-7.0	41204-J	17010-J	
5.2-8.6	41204-H	17010-H	
6.4-10.6	41204-G	17010-G	
8.3-13.7	41204-F	17010-F	
10.3-17.1	41204-E	17010-E	
13.0-21.0	41204-D	17010-D	
16.5-26.3	41204-C	17010-C	
21.0-35.4	41204-B	17010-B	
27.0-45.2	41204-A	17010-A	
34.0-55.5	41204-T	17010-T	
91.5-164.7	41204-T3	17010-T	3,000
187.5-345.0	41204-T1	17010-T	8,000
47.4-71.6	41204-S	17010-S	

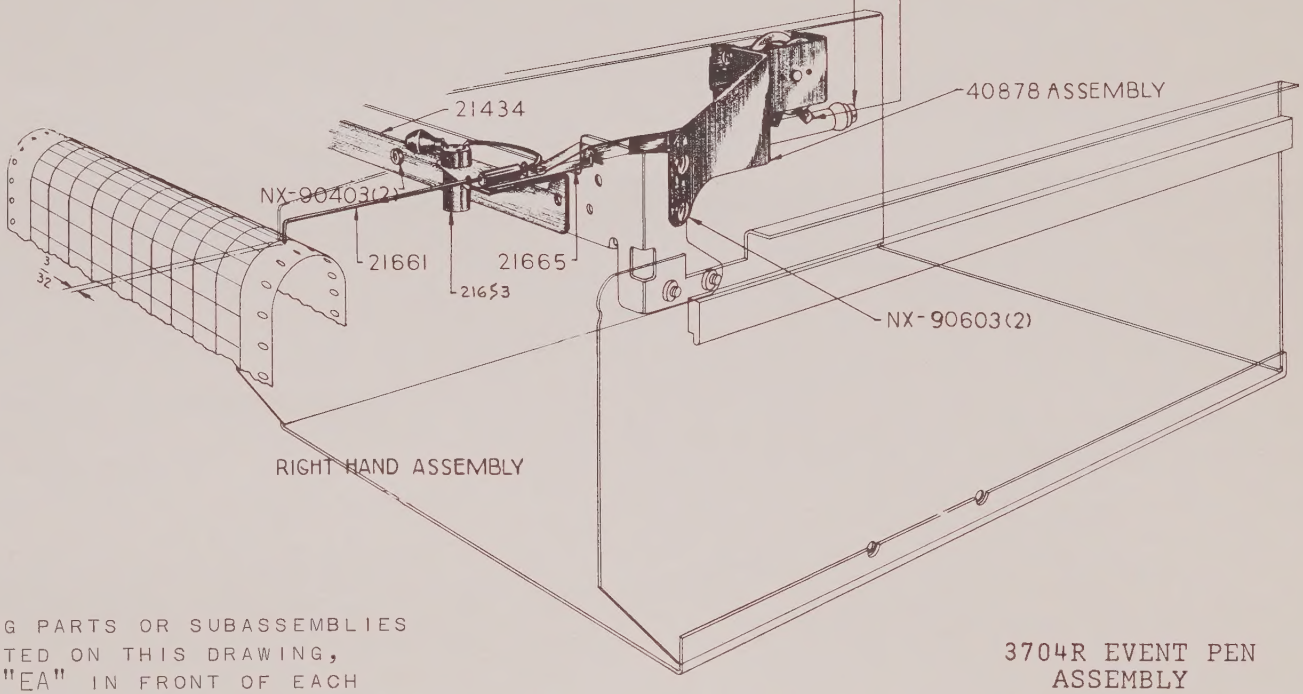
AC RATINGS (60 CPS.)

VOLTAGE RANGE	RIGHT HAND ASSEMBLY NO.	COIL NO.	SERIES RESISTANCE TUBE OHMS
2.72-4.08	41204-P	17010-P	
4.44-6.85	41204-N	17010-N	
8.8-13.2	41204-K	17010-K	
19.2-26.8	41204-G	17010-G	
96.0-144.0	41204-T	17010-T	
183.1-284.9	41204-T2	17010-T	7,000

PARTS REQUIRED FOR SERIES RESISTOR MOUNTING

SCREW NX-40648(2)
NUT NX-2006(2)
LOCK WASHER X-106(2)
WASHER NX-1106(2)
SPACER 8685(4)
10 WATT RESISTOR NO. 20222 (SEE TABLE)

NOTE: COIL TABS DOWN



NOTE: WHEN ORDERING PARTS OR SUBASSEMBLIES BY PART NUMBERS LISTED ON THIS DRAWING, INSERT THE LETTERS "EA" IN FRONT OF EACH PART NUMBER SO AS TO INDICATE OUR SUPPLIER AND AVOID DELAY.

3704R EVENT PEN ASSEMBLY

KEITHLEY INSTRUMENTS, INC.
12415 EUCLID AVENUE CLEVELAND, OHIO 44106